Coastal and Semi Enclosed Seas

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LONG-TERM GOALS

To develop, test, demonstrate and evaluate nowcast/forecast systems for coastal and semi-enclosed seas. These systems are developed and tested in this 6.2 program and then transitioned into a 6.4 program for final evaluation and testing under near real time operational conditions.

OBJECTIVES

The objective of this project is to determine the important processes that affect the oceanography of semi-enclosed seas, both deep and shallow, that are of Navy interest. This is accomplished through the use of a combination of numerical models and observations, including the assimilation of data. Which processes are included in the numerical models depends upon their importance in relationship to the region of Navy interest being modeled. As an example, tides are more important in shallow than in deep semi-enclosed seas. Once the appropriate model is developed and tested in the region of Navy interest, it is transitioned into the U.S. Navy's 6.4 programs for advanced developmental testing before transition into operations, the ultimate goal of the project.

APPROACH

Numerical model process and sensitivity studies are conducted to better understand the dynamics and thermodynamics of shallow and deep semi-enclosed seas. This is accomplished by both developing/adapting models to regions of key Navy interest and verifying those models against available observations. In addition to the numerical models, data assimilation techniques are developed/tested and implemented to improve the models predictive skill. The thrust of the project this year was the development and testing of a numerical model for the East Asian Seas (EAS) encompassing the South China Sea, Yellow Sea and the Sea of Japan and a coarser resolution model of the entire North Pacific (NPAC). The Princeton Ocean Model (POM) and the Navy Coastal Ocean Model (NCOM) were adapted to these areas. Several different boundary conditions were tested on the EAS model including the use of NPAC temperature, salinity and ocean currents as boundary conditions. Results of this testing pointed to the need for global ocean boundary conditions, not only for the EAS model but for similar models in different areas of Navy interest. In addition, tests assimilating synthetic temperature and salinity profiles were successfully performed on the NPAC

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model. Key individuals working on this project are: Dr. Dong Shan Ko (Co-PI), development of POM codes for the North Pacific Ocean (NPAC) and East Asian Seas (EAS), development of real-time demonstration of a 72-hour forecast capability for the NPAC system including the assimilation of synthetic temperature and salinity data derived from the Modular Ocean Data Assimilation System (MODAS); Paul Martin, setting up and testing NCOM codes in the global, NPAC and EAS domains. Shelley Riedlinger, running both EAS and Yellow Sea model codes: Pamela Posey obtains and provides atmospheric forcing, both real time and archived to this project.

WORK COMPLETED

It had been determined in this project last year, that boundary conditions were a key to accurate modeling of any of the semi-enclosed seas included in this project. After several unsuccessful attempts were made to use climatology or the barotropic transports and sea surface elevation information from the Navy Layered Ocean Model as boundary conditions for the EAS model, the decision was made to demonstrate the use of a coarse resolution (1/4-1/3^0) global ocean model that contained the detailed vertical structure of temperature, salinity and ocean currents needed by the EAS model. Although a 1/4 ^{0} global ocean grid was designed for this purpose, the demonstration of the value and use of this type of model for providing boundary conditions was done over a more limited domain, that being a 1/4^0 model of the North Pacific Basin. This model extends from 15^0 S latitude to 60^0 N latitude. Testing of this model included a spin-up of the model from 1994 to 1999 using the Navy Operational Global Atmospheric Prediction System (NOGAPS) data.

Once the NPAC model runs were complete, this model provided boundary conditions for the EAS model (1/8^0 simulation). A year test of the EAS model was run. During that time the currents, temperature and salinity at the boundaries was closely examined for instabilities or other problems. No such problems were observed during these test.

An additional task under this project was the testing of the new Navy Coastal Ocean Model (NCOM) code being developed in the ONR Ocean Model Development for COAMPS project. This model was first set up on the NPAC domain and a several year test was run comparing the NCOM and POM versions of the NPAC model. Next the EAS model was set up using the NCOM code and run with boundary conditions supplied by the NPAC model. This "demo" of an EAS NCOM run with boundary conditions from the NPAC model has been run for 2 years and is continuing to run.

In addition, a global 1/4^0 grid, including both the north and south poles was developed. The associated model topography and coastlines were also set up. The NCOM model was applied to this domain using both 1/2 and 1/4 degree resolution. The model was run for both cases using climatological forcing for at least 2 years.

The global work was put on hold until a demonstration was set up over a smaller domain, the NPAC domain, that would show the forecasting capability of such a model. For this task the original POM code was used in the NPAC (1/4^0) region (for simplicity as it was already set up at the time this "demo" was suggested). Real-time 72-hour forecasts from NOGAPS (every 3-6 hours) are used to drive the NPAC model. In addition, synthetic temperature and salinity data derived from the MODAS synthetics are continuous assimilated (via nudging) into this model. The NPAC ocean model provides a 72-hour, 3-D forecast of ocean temperature, salinity and currents each day.

Although we have not included figures of model results in this report, output from these forecasts are now publicly available through the NRL website listed under the title of this document and we would urge researchers with an interest in this system to visit this website.

The EAS model will be run longer during the next fiscal year before transition to the 6.4 SPAWARS Small Scale Oceanography program.

RESULTS

The EAS POM model was run using barotropic transports and sea surface heights derived from a 6-layer version of the Navy Layered Ocean Model (NLOM). These boundary conditions had previously been applied successfully to a POM model along the west coast of the United States. However, the EAS open boundary extends across a much larger area. In this region the baroclinic part of the circulation is critical and cannot be ignored. As a result the EAS model only ran successfully for approximately one year using the barotropic transports and height fields from NLOM. The use of climatology was also unsuccessful as the boundary crosses the equator and the calculation of geostrophic ocean currents were not appropriate for this region.

As the Navy often requires ocean environmental information at varying global locations on short notice, the concept of globally relocatable models is becoming more of a necessity. Such relocatable ocean models require boundary condition information similar to that needed by the EAS model. Therefore a larger domain model (using coarser resolution) will be required to provide the necessary boundary conditions for these relocatable and regional models. This project has demonstrated a model, maintaining sufficient vertical resolution, that can provide such boundary conditions. Although POM has been used to demo this capability, a more flexible code, such as the NCOM code may provide a more accurate representation of the shelf, slope and deep water through the use of its hybrid coordinate system (the capability of a sigma and/or z vertical coordinates).

The "real-time demo" of the NPAC model, providing a 72-hour forecast of ocean temperature, salinity and currents showed the ability of such a model to run in a forecast mode and the value added to the forecast by data assimilation. This is particularly visible on the eddy structure in the Kuroshio extension region of the Pacific Ocean. This demo has now been made available as a public website. The system will continue to be validated by NRL and we anticipate that outside researchers who can now access these results may also provide input on the validation of this system.

Initial results of the Global version of NCOM showed promising results. This work will continue as part of the Basin Scale modeling project funded under the NOMP program at NRL.

IMPACT/APPLICATIONS

The impact of this project has been to show the usefulness of codes like the POM for predicting the dynamics and thermodynamics of both shallow and deep marginal seas. This project has also shown the need for sufficient detail in both the barotropic and baroclinic components of the ocean circulation at the open boundaries. This project has also demonstrated the capability of using POM or a POM-like code, using simple assimilation schemes for the prediction of 3-D ocean temperature, salinity and currents.

TRANSITIONS

Both the EAS model and the large scale model that will provide boundary conditions to the EAS model will be transitioned into the 6.4 SPAWAR Small Scale Oceanography program. After the appropriate testing these code will be transitioned to the Fleet Numerical Meteorology and Oceanography Center (FNMOC) for operational implementation and testing.

RELATED PROJECTS

NRL 6.1 LINKS project. Gregg Jacobs PI. Looks at the interaction of the three Western Pacific marginal seas.

SPAWAR 6.4 Small Scale Oceanography project. Tests coastal ocean models in a real time forecasting scenario before they are delivered into operations.

ONR funded Sea of Japan project. This project investigates the circulation in the Sea of Japan using both field observations and numerical ocean models.

ONR funded COAMPS project.

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